

CLAIMS:

1. A brake device which is adapted for a motor vehicle and has a braking means that applies brake force according to brake fluid pressure to a rotator
5 fixed to a wheel, the brake device is characterized in that the brake device has a pressure-reducing means for applying reaction force inputted from the rotator to the braking means in a brake operation in a reducing direction of the brake fluid pressure.
- 10 2. The brake device according to claim 1, wherein the pressure-reducing means is provided with a valve means capable of shifting maintenance and reduction of the brake fluid pressure, and applies the reaction force inputted to the braking means in the reducing direction of the brake fluid pressure in the valve means.
- 15 3. The brake device according to claim 1 or claim 2, wherein a brake reaction force detecting mechanism is provided for detecting the reaction force inputted to the braking means, so that the detected reaction force is applied to the valve means in the reducing direction of the brake fluid
20 pressure.
4. The brake device according to any one of claims 1 to 3, wherein the brake reaction force detecting means is provided swingably relative to a vehicle body side, and integrated with the braking means so that the reaction
25 force inputted to the braking means can be transformed into a swing movement.

5. The brake device according to claim 4, wherein
a drive device is provided to apply driving force to the wheel, and the brake
reaction force detecting means includes a machine-side cylindrical case
5 containing the drive device.

6. The brake device according to claim 4, wherein
a rotating electric motor is provided for applying regenerative brake force to
the wheel, and the brake reaction force detecting means includes a machine-
10 side cylindrical case containing the rotating electric motor.

7. The brake device according to any one of claims 4 to 6, wherein
the machine-side of the rotating electric machine is rotatably supported by a
vehicle body side member, the vehicle body side member is formed with an
15 on-demand brake fluid pressure chamber, a wheel-cylinder fluid pressure
chamber and a return fluid pressure chamber, an orifice is provided in a
communicating fluid pressure passage between the on-demand brake fluid
pressure chamber and the wheel-cylinder fluid pressure chamber, a wheel-
cylinder fluid pressure modulator valve is provided in a communicating fluid
20 pressure passage between the wheel-cylinder fluid pressure chamber and the
return fluid pressure chamber, and
the pressure-reducing means is a mechanical feedback mechanism for
modulating the wheel cylinder fluid pressure so that the sum torque of the
regenerative brake torque that is applied through a working arm provided on
25 the machine-side cylindrical case in the opening direction and fluid pressure
brake torque due to the wheel cylinder fluid pressure in the opening direction

can be balanced with the on-demand brake torque due to the on-demand brake fluid pressure.

8. The brake device according to claim 7, wherein

5 the rotating electric machine is an in-wheel electric motor with reduction gears, in which the electric motor and the reduction gears are arranged in the machine-side cylindrical case fixed to an integral brake caliper in a driving wheel,
the wheel-cylinder fluid pressure modulator valve has a piston and a valve
10 member connected with the piston, where one end portion of the piston is in the on-demand brake fluid pressure chamber to receive torque in a closing direction of the wheel-cylinder fluid pressure modulator valve when the on-demand brake fluid pressure is generated and the valve member opens and closes a valve hole formed in a partition wall between the wheel-cylinder
15 fluid pressure chamber and the return fluid pressure chamber, and
the mechanical feedback mechanism is a first feedback mechanism modulating the wheel cylinder fluid pressure so that torque applied to the piston through the working arm provided on the machine-side cylindrical case in the opening direction can be balanced with the on-demand brake torque
20 acting in the closing direction and determined by the product of the on-demand fluid pressure and an effective pressure receiving area of the piston.

9. The brake device according to claim 7, wherein

the rotating electric machine is an on-vehicle electric motor with reduction
25 gears, in which the electric motor and the reduction gears are arranged in the machine-side cylindrical case which is separated from a brake caliper in a

driving wheel,
the wheel-cylinder fluid pressure modulator valve has a first piston and a valve member connected with the first piston, where one end portion of the piston is in the on-demand brake fluid pressure chamber to receive torque in a closing direction of the wheel-cylinder fluid pressure modulator valve when the on-demand brake fluid pressure is generated and the valve member opens and closes a valve hole formed in a partition wall between the wheel-cylinder fluid pressure chamber and the return fluid pressure chamber,
the vehicle body side member is formed with a second wheel-cylinder fluid pressure chamber provided with a second piston at a position distanced from the wheel-cylinder fluid pressure modulator valve,
the machine-side cylindrical case is provided with a second working arm receiving torque from a piston rod of the second piston in the opening direction when the wheel cylinder fluid pressure is generated, and
the mechanical feedback mechanism is a second feedback mechanism modulating the wheel cylinder fluid pressure so that torque applied to the first piston through the first working arm provided on the machine-side cylindrical case in the opening direction can be balanced with the on-demand brake torque acting in the closing direction and determined by the product of the on-demand brake fluid pressure and an effective pressure receiving area of the first piston.

10. The brake device according to claim 9, wherein
the rotating electric machine is an on-vehicle electric motor with reduction gears, in which the electric motor and the reduction gears are arranged in the machine-side cylindrical case which is separated from a brake caliper in a

driving wheel,
the wheel-cylinder fluid pressure modulator valve has a first piston, a second piston and a valve member connected with the first piston and the second piston, where one end portion of the first piston is in the on-demand brake fluid pressure chamber to receive torque in the closing direction when the on-demand brake fluid pressure is generated, one end portion of the second piston is in the wheel-cylinder fluid pressure chamber to receive torque in the opening direction when the wheel cylinder fluid pressure is generated, and the valve member opens and closes a valve hole formed in a partition wall between the wheel-cylinder fluid pressure chamber and the return fluid pressure chamber, and
the mechanical feedback mechanism is a third feedback mechanism modulating the wheel cylinder fluid pressure so that the sum torque of torque applied to the first piston through the first working arm provided on the machine-side cylindrical case in the opening direction and fluid pressure brake torque acting in the opening direction and determined by the product of the wheel cylinder pressure and an effective pressure receiving area of the second piston can be balanced with the on-demand brake torque acting in the closing direction and determined by the product of the on-demand brake fluid pressure and an effective pressure receiving area of the first piston.

11. The brake device according to any one of claims 7 to 10, wherein the on-demand brake fluid pressure chamber is a master-cylinder fluid pressure chamber conducting master cylinder fluid pressure generated by a master cylinder according to a brake operation of a brake operating means.

12. The brake device according to any one of claims 7 to 10, wherein
the on-demand brake fluid pressure chamber is an ABS brake fluid pressure
chamber conducting ABS brake fluid pressure from an Antilock Brake
5 System provided at a downstream side of a master cylinder.

13. The brake device according to claim 12, wherein
a brake control means is provided for stopping regenerative brake by the
rotating electric machine in an Antilock Braking system operation.

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14. The brake device according to claim 1 or claim 2, wherein
the brake reaction force detecting means is a torque sensor that electrically
detects reaction force of the fluid reaction force inputted to a brake caliper,
and
15 the pressure reducing means is an electric feedback circuit that controls the
pressure-reducing solenoid valve for decreasing the brake fluid pressure
according to a torque value detected by the torque sensor.

15. The brake device according to claim 14, wherein
20 the rotating electric machine is an in-wheel electric motor with reduction
gears, in which the electric motor and the reduction gears are arranged in the
machine-side cylindrical case fixed to an integral brake caliper in a driving
wheel, and
the electric feedback circuit includes a pressure-reducing solenoid valve
25 arranged between a wheel-cylinder fluid pressure passage conducting ABS
brake fluid pressure from an Antilock Brake System provided at a

downstream side of a master cylinder to a wheel cylinder and a return fluid pressure passage fluidically connected with a fluid pump inlet port side of the Antilock Brake System to control the pressure-reducing solenoid valve according to torque value detected by the torque sensor.

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16. The brake device according to claim 14, wherein the rotating electric machine is an on-vehicle electric motor with reduction gears, in which the electric motor and the reduction gears are arranged in the machine-side cylindrical case which is separated from a brake caliper in a driving wheel, and

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the electric feedback circuit includes a pressure-reducing solenoid valve arranged between a wheel-cylinder fluid pressure passage conducting ABS brake fluid pressure from an Antilock Brake System provided at a downstream side of a master cylinder to a wheel cylinder and a return fluid pressure passage fluidically connected with a fluid pump inlet port side of the Antilock Brake System to control the pressure-reducing solenoid valve according to torque value detected by the torque sensor.

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17. The brake device according to claim 4, wherein only the braking means is provided for applying fluid pressure brake force to the wheel, and

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the brake reaction force detecting means is a caliper member integrally formed with a brake caliper of the braking means.